<u>Wetlands, climate change and the carbon cycle</u>

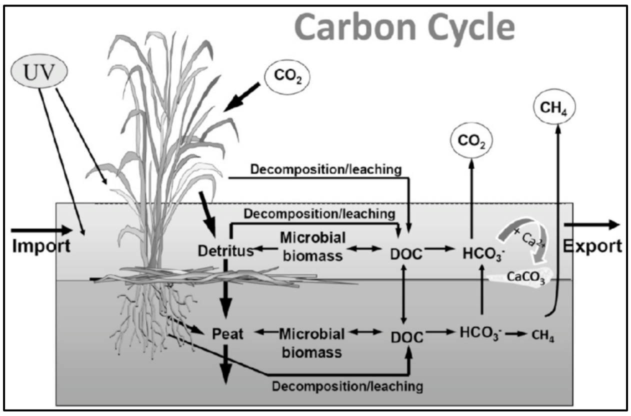
Introduction

Wetlands are environments at the fringes of aquatic and terrestrial ecosystems – this includes the presence of ice (e.g. active layer overlying permafrost).

- Over time, particularly in warm and wet environments, the growth of mossy vegetation can form considerable depths of peat bogs.
- Moss sequestrates (slowly) and stores carbon from the atmosphere forming an important carbon sink (Figure 1). Huge quantities of carbon are held within wetlands, roughly equivalent to that held within the atmosphere.

Figure 1

Wetland generalised carbon cycle



https://www.researchgate.net/figure/A-generalized-depiction-of-the-carbon-cycle-in-wetlands-including-the-major-storage_fig3_274638205

- Wetlands release methane (due to decomposition) into the atmosphere

Feedback loops

Negative feedback – growth of moss and expansion of wetlands (peatlands) increases carbon sequestration, reducing carbon in the atmosphere

Positive feedback – carbon and methane released from wetlands, particularly associated with drainage, deforestation and fires, increases greenhouse gases in the atmosphere

Wetlands under threat

Wetlands across the world are responding to changes in the climate. Those in extreme environments, such as polar (Arctic/Antarctic) and tropical are most vulnerable to change.

Antarctic

The Antarctic Peninsula region, (e.g. Elephant Island) is experiencing rapid temperature increase. This has led to an increase in the growth and extent of moss creating a negative feedback and increasing carbon sequestration from the atmosphere. Similar evidence (expansion of moss coverage) exists in Svalbard where there has been a 4°C increase in temperature in the last 50 years.

Arctic

In the Arctic, lenses of ice exist within the soil forming low mounds called **palsa**. Warmer temperatures have melted the ice resulting in subsidence and the formation of myriad thaw ponds. This process results in emissions of gases particularly methane, which enhances the greenhouse effect . . . a positive feedback, leading to higher temperatures and more melting.

Figure 2

Palsa, Tosilappi, Finland

https://www.tosilappi.fi/en/palsa-moors/

Tropical

Significant expanses of tropical rainforests (e.g. Congo) are underlain by muddy wetlands which store vast quantities of carbon. Human activity involving deforestation and subsequent draining of land for agriculture (rice, oil palms, ranching) has resulted in the drying out of the wetlands and the release of carbon and methane. Indonesia is the fourth highest emitter of carbon (2015) and much of this is due to fires associated with forest destruction (https://www.carbonbrief.org/the-carbon-brief-profile-indonesia).

Temperate

Temperate wetlands were very widespread in the past (Fens, Netherlands, Somerset Levels) but drainage for agriculture and settlement has reduced this area significantly. Peat has been extensively dug for heating but particularly for horticulture (Figure 3), releasing greenhouse gases. Drainage of uplands for farming has also led to a loss of peatlands.

Figure 3

Commercial peat extraction, Auchencorth Moss, Midlothian, Scotland

https://community.rspb.org.uk/ourwork/b/scotland/posts/peat-bog-destruction-needs-to-stop-but-how

Responses

Restoration of wetlands can be very effective in restoring the carbon balance such that peatlands can once again become net carbon sinks, regenerating the negative feedback loop.

This commonly involves blocking drainage ditches to allow water accumulation which promotes the growth of moss and restoration of peatlands.

Examples include Exmoor Mires Restoration Project (Figure 4) and Badan Restoras Gambut (https://www.id.undp.org/content/indonesia/en/home/projects/Support-Facility-for-the-Peat-Restoration.html) which involves restoring wetlands in tropical Indonesia (Figure 5).

Figure 4

Exmoor Mires Restoration Project – blocking ditches to restore wetlands

Figure 5

Restoring tropical peatlands in Indonesia

Future trends

Whilst a natural cycle of change can be clearly identified - wetland change affects the climate which in turn affects wetland change - the role of people is extremely important. Human actions such as deforestation and wetland drainage can threaten and reduce wetlands resulting in detrimental change. However, recent restoration projects have proved remarkably successful in returning environments to natural wetland, promoting moss growth and sequestering carbon from the atmosphere.

It is the most vulnerable regions (polar/tropical) that are experiencing the greatest rate of change associated with climate change.

- Polar – future rapid warming (and higher rainfall) is likely to increase the rate of moss growth
- Tropics – future rapid warming (but lower rainfall) is likely to reduce the rate of moss growth

Moss growth (peatland/wetland development) seems likely to increase latitudinally from polar to temperate but then decrease from temperate to tropical.

Arctic peatlands seem likely to grow most rapidly thereby increasing (slowly) rates of carbon sequestration (negative feedback). But, as temperature rises further, the extensive losses of temperate and tropical wetlands will outweigh the growth taking place in the Arctic. This will increase the rate of methane/carbon emissions leading to a positive feedback. Volumes and timescales are critical controls here in assessing the overall impacts of climate change on wetlands and vice versa.

Based on lecture by Professor Dan Charman (Exeter), Plymouth 22/11/19